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Selection Management in Southern Appalachian Hardwoods

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ABSTRACT. A woodland tract of southern Appalachian cove hardwoods and mixed oak has been munaged under the selection satem of silviculture since 1946. Simply cutting in all commercial diameter classes (i.e., 6.0 inches and larger), as was the practice during thefirst 24 years, failed to develop enough desirable saplings and poles to maintain the system. After 1970, herbicide treatment of undesirable, tolerant understory species in openings created by removal of large trees or groups of trees has improved the status of desirable saplings. Although long-term costs of management and yields are uncertain, the study suggests that creation of larger openings and treatment of undesirable understory species offers at least a chance for success with the selection system in southern Appalachian hardwoods.

Management of eastern hardwood forests by selection methods of silviculture has produced mixed results and a great deal of controversy. Xrguments pro and con are a mixture of biologic and economic considerations that are not easily generalized. The selection system, however, seems to work best for species that are highly tolerant of shaded conditions and where profitable production of timber on a sustained basis is not the paramount aim of managemement. Despite these limitations, the appeal of the selection system is still great, particularly for the small, private woodland owner. Manv such owners would like to be able to use the selection system even though it might produce less than ideal results from a timber-production standpoint.

Documented here is a sustained attempt to manage southern Appalachian hardwoods with the selection system. The study covers a sizable area with variable site conditions and species composition and. most important, a relatively long period of observation. The study points up particular problems with the system under southern Appalachian conditions and suggests modifications that give che system greater flexibility.

THE WOODLAND

The 103.8acre woodland on che Bent Creek Experimental Forest near Asheville, North Carolina (Figure 1), occupies a northeast-facing cove and surrounding slopes at an average elevation of 2,500 ft. Approximateiy 10 acres in the central secrion, along a small intermittent stream, are relatively flat (21% slope), with a rolling phase Tusquitee loam (Humic Hapludult). About one-half of the woodland soil is Haiewood loam (Typic Hapludult) ranging from 15 to 30% slope; the remainder is mostly Porters stony loam. sreep phase (humic hapludult), wirh slopes ranging from 30 to 60%. Soil moisrure relationships and soils within the area are generally conducive to producing high-quality hardwoods. Rainfall is well distribured throughout the year. averaging about 50 in. The growing season averages 180 days.

Historically the area is typical of much of the southern Appalachians. It was settled around 18 10; small tracts in the central portion were cleared for fields and the remaining woodland was subjected to grazing, periodic high-grading, and burning for about 80 years. Agricultural activities were phased out between 1900 and 1920, and rhe area was protected from fire and grazing. Abandoned fields reverted to foresr and new growth and regeneration took place in the woodland portions. By 1946, when this study began. che woodland consisted of even-aged patches of trees of varying size and ranging from 30 to 50 years in age intermingled with scanered

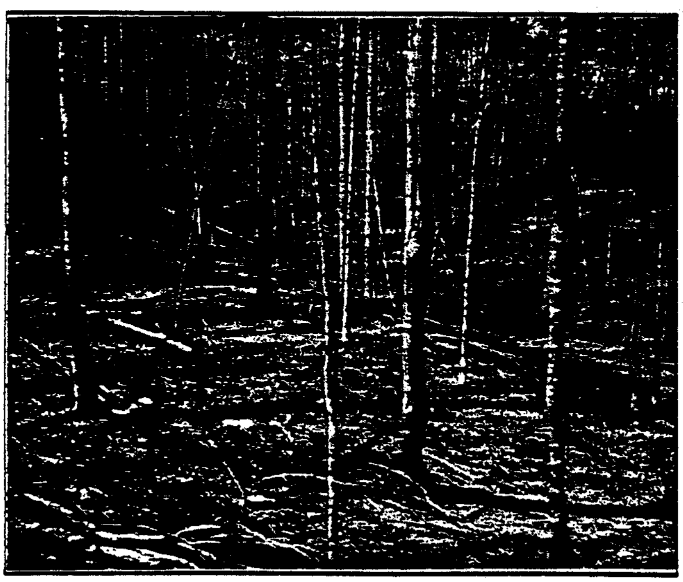

Figure 1. Single-tree selection cutting on the Bent Creek Experimental Forest near Asheville, North Carolina.

large trees from 100 to 200 years old and mostly of very low quality. In 1946 the woodland was carrying an average of 6,793 bd ft (Int. 1/4-inch rule) plus about 9 cords of pulpwood per acre. Basal area averaged 72 sq ft per acre in 122 trees ≥ 6.0 in dbh (Table 1). In terms of composition by basal area, the woodland contained about 50% oak-20% chestnut (*Quercus prinus*), 17% scarlet (Q. coccinea) and black (*Q. velutina*), 8% white (*Q. alba*), 5% northern red (*Q. rubra*)—26% yellow-poplar (*Liriodendron tulipifera*), 3% miscellaneous desirable hardwoods,[1] 13% miscellaneous undesirable hardwoods,' and 8% yellow pine (*Pinus* spp.).

MANAGEMENT

The objectives of the management study were to:

(1) Improve the quality of the woodland in species composition and bole quality.
(2) Produce periodic income—preferably annual-from timber harvest.
(3) Develop a balanced stand structure capable of sustaining periodic harvest.

The single-cree selection system of silviculture was chosen as a logical means to achieve these goals. During the early years, emphasis was placed on stand improvement bv removal of sawtimber trees of low vigor, a simulation of whar a cypical mountain farmer could do in his spare time with available farm equipment. Consequently, it took 10 years to completely cover the entire woodland with light improvement cuts.

In 1956 the first formal steps were taken roward achieving a balanced diameter distribution. At that time the de Liocourt (Meyer et al. 1952) technique for controlling diameter distribution was iniriated. Target Q values. i.e., the average quocient between number of trees in successively smaller dbh classes, ranged from 1 .5 to 1.8 over different parts of rhe woodland depending on species composirion. The idea of the owner cutting his own timber and selling logs at roadside or the mill was abandoned and commercial stumpage sales were initiated. Consequently, no cutring was done from 1936 to 1962 to allow sufficient salable volume to accumulate.

In all cuw after 1936. harvesring took place over the entire woodland and an attempt was made to harvest trees in all size classes to achieve a balanced diameter distribution. Table 2 summarizes the total harvest over the 38-year period on the entire 103.8 acres. Sixty-seven percent of the 6- to 10-in trees cut were tolerant. undesirable understorv species. Ten

[1] Includes sweer birch (*Betula lenta*), black locust (*Robinia pseudoacacia*), hickory (*Carya* spp.), and cucumbertree (*Magnolia acuminata*).
[2] Includes red maple (*Acer rubrum*), dogwood (*Cornus florida*), sourwood (*Oxydendrum arboreum*), blackgum (*Nyssa sylvatica*), beech (*Fagus americana*), and sassafras (*Sassafras albidum*).

Table 1. Stocking by species, Bent Creek Experimental Forest, Asheville, North Carolina, 1946.

Diameter class	Pine	Mixed oak	White oak	Chestnut oak	Northern red oak	Yellow-poplar	Locust	Misc. desirable	Red maple	Misc. undesirable	Total
Inches						*Number/acre*					
						1946					
6-10	15.3	9.1	5.2	9.0	1.8	13.1	5.5	4.8	6.0	14.3	84.1
12-16	3.9	5.2	1.8	3.6	1.0	8.6	1.2	0.9	1.2	0.2	27.6
18-22	0.2	3.3	0.8	1.8	0.3	2.2	0.1	0.1	0.2	<.01	9.0
24-28	—	0.2	0.3	0.6	0.06	0.2	—	—	< .01	—	1.3
30-34	—	0.06	0.01	0.2	0.02	0.01	—		—	—	0.3
36-42	—	0.03	—	0.07	—	—	—	—	—	—	0.1
	19.4	17.9	8.1	15.3	3.2	24.1	6.8	5.8	7.4	14.5	122.4
						1983					
6-10	1.3	3.4	2.4	6.3	1.3	4.5	2.7	6.5	8.0	19.6	56.0
12-16	1.2	2.8	1.7	4.4	0.8	5.0	0.4	0.8	0.6	0.2	17.9
18-22	0.2	2.2	1.0	3.4	0.7	5.4	0.1	0.1	0.2	<.1	13.3
24-28	<.1	0.5	0.4	0.8	0.4	1.8	—	<.1	<.1	—	4.2
30-34	—	<.1	0.1	<.1	0.1	0.2	—	—	—	—	0.6
36-42	—	—	—	—	<.1	<.1	—	—	—	—	<.1
	2.7	9.1	5.7	15.0	3.3	17.0	3.2	7.4	8.8	19.8	92.0

percent of the pulpwood cut was yellow pine. About 24% of the pulpwood cut was oak, yellow-poplar, and other desirables competing with better formed stems of the same species group.

In 1970 a *Q* of 1.4 was selected for the entire woodland with a target basal area of 60 sq ft per acre and a maximum diameter of 36 in. The marking guide called for:

Size class	Trees per acre
5 to 12 in dbh	100
13 to 20 in dbh	21
21 + indbh	4
Total	123

Table 2. Number of trees cut 1946–1984 on entire woodlot, Bent Creek Experimental Forest, Asheville, North Carolina.

Dbh	Desirable species	Undesirable species[1]	Total
Inches		*Number*	
6	438	1.741	2,179
8	604	855	1,459
10	596	447	1,043
12	545	232	777
14	413	103	516
16	350	54	404
18	227	33	260
20	168	23	191
22	128	6	134
24	93	6	99
26	59	—	59
28	41	—	41
30	29	—	29
32	26	—	26
34	7	—	7
36	4	—	4
38	1	—	1
40	1	—	1
42	1	—	1

[1] Includes red maple.

In 1970 the relativelv heavv harvest resulted in numerous openings rím'ging up to a 1/4-acre in size where two or more trees were removed in groups. Two years later, understorv species up to 8.0 in dbh in those openings—mainly red maple, dogwood, and sourwood —were injected with herbicide to release desirable seedlings and saplings.

VOLUME AND QUALITY CHANGE

By 1983 volume per acre had increased to 8,3 12 bd ft. During the 38-year period from 1946. a total of 561,250 bd ft were harvested from the woodland. averaging 5,407 bd ft per acre. Volume harvested plus the net gain of 1,5 19 bd ft give a total net growth of 6,926 bd ft per acre, or annual net growth of 182 bd ft. The current rate of growth, however. is substantiallv better than the average for the period. Between 1975 and 1983 the woodland has grown at an approximate rate of 260 bd ft per acre per year.

While total growth and net change in volume have been relatively low, change in quality has been substantial. In 1946, 90% of all sawtimber volume was in trees with a butt log of Grade 3 or less. Onlv 2% of the volume was in trees with Grade 1 butt logs. In 1983, because of increased size and removal of inferior trees, 42% of sawtimber volume was in Grade 1 trees, 44% was in Grade 2, and onlv 14% of sawtimber volume was in Grade 3 trees and below.

STAND STRUCTURE AND SPECIES COMPOSITION

Since the study began, there have been some striking changes in numbers of trees and diameter distribution of species (Table 1). The most obvious change has been a 25% reduction in number of trees 6.0 in and larger. Of this 30-tree-per-acre decrease,

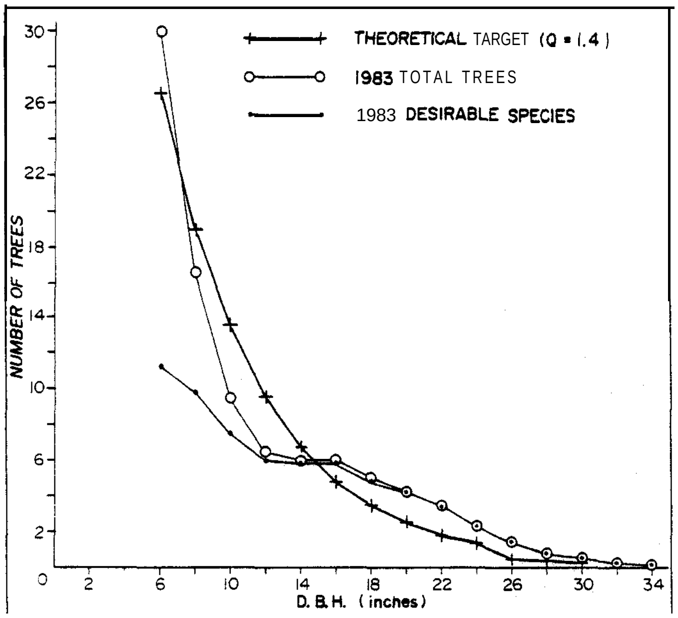

Figure 2. Diameter distribution, for the woodland in 1983 compared with that for a theoretical balanced uneven-aged stand for a Q of 1.4.

28 were 6- to 10-in poles and saplings. The reduction in poles and saplings included mostly oak and yellow-poplar in addition to pine. Yellow pine was heavily cut and was practically eliminated. Poles and saplings of oak, yellow-poplar, and other desirable species that grew into large size classes were not replaced by recruitment from smaller size classes. At the same time, red maple and other tolerant understory species (mainly dogwood and sourwood) increased in absolute numbers and proportion of trees in the sapling and small pole classes despite a concerted effort to reduce their numbers. Of all stems cut in the 6-in class, 80% were red maple, dogwood, and sourwood. Sixty-five percent of all stems cut in 6- to 10-in classes, inclusive, were these species. In addition, 25 stems per acre, 8 in and under, were deadened in small openings in 1972. But regardless of this attrition, more than enough trees of the tolerant understory species were recruited into the sapling and small pole classes from smaller size classes to cause an increase in their numbers. Diameter distribution for the woodland in 1983 compared with that for a theoretical balanced uneven-aged stand for a Q of 1.4 is shown in Figure 2. If the tolerant understory trees are excluded, the 1983 distribution resembles the truncated normal distribution observed in numerous even-aged hardwood stands more than it does the theoretical distribution needed to perpetuate uneven-aged stands.

RECENERATION

Given the failure to recruit desirable species into the sapling and small pole classes (6 to 10 in), what are the causes? And what is the future outlook for the stand? To answer these questions we looked at reproduction in two categories: seedlings less than 4.5 ft tall and saplings 1 to 6 in dbh.

Table 3. Seedling reproduction <4.5 feet tall on woodland study area, Bent Creek Experimental Forest, Asheville, North Carolina.

Year	Desirable species	Undesirable species	Total
	............Number............		
1970	11,805	28,344	40,149
1975	18,651	17,886	36,537

Seedling Reproduction

Reproduction less than 4.5 ft tall was tallied in 1970 and again in 1975 (Table 3). These numbers confirm what we have found in southern Appalachian stands on good sites under a variety of harvest cutting methods. That is, the total number and proportion of seedlings by species may vary from time to time, but seedlings of all species are constantly being established, and large numbers exist at any one time. Even the so-called intolerant species are generally present. In 1975, for example, there were 11,000 yellow-poplar, 5,000 oak, and 2,500 stems of other desirable species along with the thousands of more tolerant and less desirable species such as red maple, dogwood, and sourwood.

Sapling Reproduction

Sapling reproduction less than 6 in dbh is shown in Table 4. In 1970 there was a paucity of stems of desirable species. Most of those present were only 1 to 2 in dbh. They were considerably outnumbered—more than 4 to 1-by tolerant undesirable saplings, which were mostly 4 to 6 in dbh. By 1975, however, there was a general increase in saplings with a slight shift toward more desirable species. By 1983, desirables had increased nearly 3-1/2-fold, and their competitive position was improved in terms of both relative proportion and size. Although still outnumbered by 4 to 1 by undesirables in 1970, they were outnumbered by less than 2 to 1 in 1983. It remains to be seen if this trend will continue, but it does suggest that larger openings and treatment of undesirable species in the openings have had a desirable effect.

From 1965 to 1970 a relatively large deer herd heavily browsed reproduction in the study area.[3] The total impact of this browsing on development of reproduction is not clear because no quantitative information was recorded. However, some of the improved development of reproduction after 1970

[3] Personal communication from C. E. McGee, Southern Forest Experiment Station, Sewanee, Tennessee. May 1984.

Table 4. Sapling reproduction <6.0 inches dbh on woodland study area, Bent Creek Experimental Forest, Asheville, North Carolina.

	1970		1975		1983	
	No./acre	Percent	No./acre	Percent	No./acre	Pefcent
Yellow-poplar	46		35		128	
Oaks	35		111		145	
Other desirable	110		157		398	
Total desirable	191	(19)	303	(23)	671	(38)
Red maple	60		121		210	
Other undesirable	756		092		881	
Total undesirable	816	(81)	1,013	(77)	1,090	(62)
TOTAL	1,007		1,316		1,761	

could be due to lessened deer impact after the herd was reduced.

AGE OF SAPLINGS AND POLES

The age structure of the stands is always in question when implementing selection systems of silviculture. Are the saplings and poles young stems or are they actually suppressed older trees? To resolve this question we sampled the age structure of saplings and poles 4 to 10 in dbh (Table 5).

Of the pole-size trees 8 to 10 in dbh, 52% were between 60 to 100 years old-essentially the same range found in the dominant stand. Only about one-fourth (22%) were less than 38 years old, indicating they had developed since the study began. Sapling-size trees 4 to 6 in dbh were somewhat younger than the poles but, again, 25% were as old as the overstory trees. About 35% of desirable saplings developed since the study was begun in 1946.

Oaks in general, and white oak in particular, were relatively old. For example, 80% of al1 white oak saplings sampled were over 80 years old and all the poles were 96 or older. The majority of desirable trees less than 38 years old were yellow-poplar and locust. While considered shade intolerant, both species are aggressive reproducers because they produce numerous seedlings and sprouts and have very rapid height growth from an early age, enabling them to compete with the understory trees.

Table 5. Age of saplings and poles on woodland study area, Bent Creek Experimental Forest, Asheville, North Carolina, by species.

Species	Saplings (4 to 6 in) Average	Saplings (4 to 6 in) Range	Poles (8 to 10 in) Average	Poles (8 to 10 in) Range
White oak	75	35-96	99	96-101
Chestnut oak	58	33-82	72	36-119
Black oak	53	37-76	63	38-178
Sweet birch	46	32-54	39	27-57
Hickory	45	22-72	72	61-83
Yellow-poplar	39	23-63	47	23-74
Locust	29	10-41	36	26-44
Red maple	44	25-71	49	31-76
Dogwood	39	15-74	52	32-66
Sourwood	36	20-77	47	17-79
Blackgum	45	23-83	49	33-62

CONCLUSIONS

After 38 years of management under the selection system, the quality of growing stock has been markedly improved. Although growth rate and income have been relatively low for the period as a whole. current growth rate of the overstory is good. Because of size and age structure, however, the future of the woodland is questionable. As the oaks, yellow-poplar, and other desirable timber species matured through successive diameter classes and were harvested, they were not replaced by the desirable saplings and poles at the level needed to maintain the system and a flow of products from the woodland. Many of the saplings and poles of desirable species that are present are old, suppressed trees with a doubtful future. Desirable seedlings and sprouts became established under the system of cutting but have generally been unable to develop in competition with the more tolerant, undesirable species—mainly red maple, dogwood. and sourwood.

During the first 24 years of the study in which trees were harvested under a single-tree selection system, the developing reproduction was dominated by the more tolerant species. This result is consistent with findings from a number of other studies in eastern hardwoods (Bramble and Fix 1980, Leak and Filip 1977, Minckler et al. 1961, Rudolph and Bresnaham 1982, Schlesinger 1976, Trimble 1940). The only problem is that in this case the tolerant species dominating the reproduction are mostly nontimber understory species or the least desirable timber species. It seems doubtful that continued management under a single-tree selection system where only merchantable trees are removed would perpetuate desirables in sufficient numbers to maintain a flow of timber products from most southern Appalachian woodlands.

However, during the 11 years since herbicide treatment of undesirable species in openings, the number and status of desirable saplings have been significantly improved. Apparently the early development of desirable species is more affected by competirion from the tolerant understory than by the surrounding overstory. It appears that creating large openings by harvesting groups of trees and eliminating the tolerant understory offers at least a chance for successful use of the selection system in southern Appalachian hardwoods. Even so, desirable saplings are still outnumbered by undesirables and it is not yet clear how well they will continue to grow in the openings. Nor is it clear what it will cost or how it will affect yield from the woodland as a whole. Roach (1974) pointed out the management difficulties of this approach where "regulation of the cut for sustained yield is high priority." But he also specuiated that it might be feasible where the sustained yield requirement is relaxed. The challenge will be to maintain sufficient stocking in desirabie sawtimber-size trees to ensure a satisfactory growth rate while at the same time providing for estabiishment of regeneration and subsequent development of desirable saplings and poles in an environment that appears to be more suitable to tolerant but unwanted species.

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